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Description

APPARATUS FOR COUPLING AN ULTRASOUND CLAMP-ON MEASURING HEAD TO BE ATTACHED TO A TUBE WALL

Technical field

The invention relates to an apparatus for acoustic coupling of ultrasound clamp-on flow measuring heads to high-temperature tube lines (greater than 150°C).

Prior art

The determination of the flow of liquid and gaseous media is extremely important in industry and metrology. Ultrasound clamp-on systems, such as are described e.g. in DE 41 14 233 C2, work completely intervention-free. In these systems, the two ultrasound measuring heads are fastened to the tube wall from outside and thereby have no direct contact to the measuring medium and do not affect the flow. The angle between sound propagation direction and flow direction of the measuring medium is determined by the law of refraction, the angle of incidence, and by the acoustic velocity of the measuring head. The transitions between the different materials of the measuring head, the tube wall, and the measuring medium run parallel to one another. The ratio of acoustic velocity and sine of the angle of incidence

$$\frac{c_i}{\sin \theta_i}$$

corresponding to the law of refraction in all associated media i is the same.

The measured flow speed is therefore the proportional to the quotient

$$\frac{c_i}{\sin \theta_i}$$

It is established by the material and geometry of the measuring heads and is identified as the sensor constant

$$k_\alpha$$

In the aforesaid ultrasound clamp-on flow measurement systems, the measuring heads are coupled directly to the tube wall. The measuring head assumes the temperature of the media and tube due to the direction transmission of heat between tube wall and measuring head. DE 41 24 692 A1 describes a special measuring head that is for use on hot objects and that is characterized by the use of temperature-resistant materials.

If the measuring medium and the tube wall have very high temperatures, e.g. greater than 200°C, the measuring head is also correspondingly heated. The severe thermal stress associated with this leads to premature aging in and the inability to function of the measuring heads, e.g. due to depolarization of the piezoceramics that are normally used as transducers. The aforesaid measuring heads for hot objects also do not have the requisite longevity for this stress.

The high-temperature measuring head suggested in US6047602 uses a special waveguide construction for transmitting the ultrasound energy into the measurement tube. This excites shear waves in the waveguide and in the tube wall.

Disclosure of the invention
Technical object

The object of the invention is based on contriving an acoustic coupling that

- permits a good acoustic coupling between a conventional clamp-on measuring head and the tube wall
- permits a pronounced difference in temperature between measuring head and tube wall so that the maximum permissible measuring head temperature is not exceeded
- causes minimal additional measurement errors for the flow speed

Technical solution

This object is inventively attained using an apparatus in accordance with claim 1. Additional advantageous embodiments are described in the subordinate claims.

Brief description of the drawings

The invention is described in the following using exemplary embodiments.

Fig. 1 depicts the coupling plate between measurement tube and clamp-on measuring head.

Fig. 2 depicts the temperature course in the coupling plate.

Exemplary embodiment(s) of the invention

In accordance with Figure 1, a specially configured coupling plate 2 is inserted between tube wall 3 and measuring head 1. The coupling plate comprises an acoustically slightly damping material that has low heat conductance, preferably special steel. The thickness

is much smaller than the other dimensions of the plate, preferably between 2 and 7 mm. The small surfaces 4 and 5 that act to conduct heat between tube wall 3 and coupling plate 2 and between coupling plate 2 and measuring head 1 admit only a slight heat flow. The heat energy conducted out of the tube therefore remains small. The large lateral surfaces of the coupling plate draw off the majority of the heat that has been fed into the plate. Therefore there is a markedly lower temperature at the measuring head coupling surface 5 than at the tube coupling surface 4, which assumes the temperature of the tube wall. The height of the coupling plate determines the difference in temperature between tube coupling surface and measuring head coupling surface.

The temperature difference between the coupling surfaces leads to a temperature profile within the coupling plate. Due to its thinness, the temperature at all plate depths is nearly the same. The temperature change within the coupling plate is linked to a change in the acoustic velocity. The path length 6 running in the coupling plate is therefore curved. The quotient that acts for the flow measurement

$$\frac{c_{Fluid}}{\sin \theta_{Fluid}}$$

therefore in general is not equal to the sensor constants.

For the special shape of the coupling plate illustrated in Fig. 2, there is a minimum deviation of the effective quotient

$$\frac{c_{Fluid}}{\sin \theta_{Fluid}}$$

from the sensor constants. It comprises a largely rectangular area for coupling to the tube that has added to it a largely trapezoidal projection to the measuring head coupling. For limiting the heat added by the tube to the coupling plate, only the area of the coupling plate that is used for the acoustic coupling is in direct contact with the tube wall. The other part of the rectangular area for coupling determines the temperature course in the coupling plate and is offset from the tube wall by a step. An analysis of the temperature course indicates isotherms 7 that are parallel to one another and that run to the tube wall in the rectangular area of the coupling plate. In this area the ratio

$$\frac{c_i}{\sin \theta_i}$$

is constant. In the upper diagonally running part of the coupling plate, the acoustic beam runs perpendicular to the isotherms. The acoustic beam is therefore not bent. Overall, the quotient

$$\frac{c_i}{\sin \theta_i}$$

that is decisive for the flow measurement is only slightly affected along the entire acoustic beam course in the coupling plate. The difference in temperature to be realized between tube wall and sensor coupling surface determines the height of the coupling plate and the length of the trapezoidal projection. The trapezoidal projection can be omitted if the temperature difference to be attained is slight (70°C).